

Age structure and growth by otolith interpretation of *Neogobius melanostomus* (Gobiidae) from Southern Black Sea

by

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ABSTRACT. - Age and growth of the round goby *Neogobius melanostomus* (Pallas, 1814) were studied by examination of growth increments within otoliths of 868 specimens caught between October 2002 and March 2005 from offshore of Samsun city in the southern Black Sea. The values of intercept and slope in length-weight relationships were calculated as 0.0110 and 3.07 for males and 0.0076 and 3.23 for females, respectively. Marginal increment analysis showed that the opaque zone was laid down in spring and summer and the translucent zone in autumn and winter. Mean lengths at age data, as derived using otolith readings, were used to estimate growth parameters of the von Bertalanffy equation. The parameters of L_{∞} , k and t_0 were calculated for males as 21.5 cm, 0.375 year⁻¹ and -0.83 year and for females as 23.7 cm, 0.223 year⁻¹ and -1.59 year, respectively. There was significant differential growth between sexes. Males attained greater length-at-age values than females. Otolith weight was a better predictor of fish length and age than other otolith dimensions. Age of males and females ranged between 1 and 5 years, while 2 and 3-year old fish were the dominant age classes in both sexes. Age-length keys indicated a great length variability within age groups which was considered as a natural outcome of intermittent spawning in round goby.

RÉSUMÉ. - Détermination de la structure en âge et de la croissance par interprétation des otolithes de *Neogobius melanostomus* (Gobiidae) de la mer Noire.

L'âge et la croissance du gobie rond *Neogobius melanostomus* (Pallas, 1814) ont été étudiés par observation de l'accroissement des otolithes de 868 spécimens capturés entre octobre 2002 et mars 2005 sur les côtes de Samsun, au sud de la mer Noire. Les valeurs d'interception et les pentes obtenues dans les relations longueur-poids sont respectivement de 0,0110 et 3,07 pour les mâles et de 0,0076 et 3,23 pour les femelles. Les analyses de l'accroissement marginal ont montré que la zone opaque s'établissait au printemps et en été, alors que la zone translucide s'établissait en automne et en hiver. Les longueurs moyennes à un âge donné, obtenues grâce à l'étude des otolithes, ont été utilisées pour estimer les paramètres de l'équation de croissance de von Bertalanffy. Les paramètres L_{∞} , k et t_0 calculés ont des valeurs de 21,5 cm, 0,375 année⁻¹ et -0,83 année pour les mâles, et de 23,7 cm, 0,223 année⁻¹ et -1,59 année pour les femelles. Une croissance significativement différente entre les deux sexes a été observée. Les mâles atteignent une longueur plus importante pour un âge donné que les femelles. Le poids de l'otolithe constitue un meilleur indicateur de la longueur et de l'âge du poisson que les autres dimensions de l'otolithe. L'âge des mâles et des femelles varie entre 1 et 5 ans alors que les poissons appartenant aux classes d'âge de 2 et 3 ans sont dominants pour les deux sexes confondus. Les clés âge-longueur soulignent une grande variabilité dans les longueurs à l'intérieur d'un groupe d'âge. Ceci est considéré comme étant la conséquence naturelle d'une reproduction intermittente du gobie rond.

Key words. - Gobiidae - *Neogobius melanostomus* - Black Sea - Turkish coast - Age - Growth - Otolith.

The round goby, *Neogobius melanostomus* (Pallas, 1814) is a demersal fish species belonging to the Gobiidae family. The coastal areas of the Black Sea and Caspian Sea, the Sea of Azov and Marmara and their tributaries are known as the native biogeographic range of this species. Though the map for European distribution of the round goby (Miller, 1986) indicates that this species does not exist along the southern shoreline of the Black Sea, it has a wide distribution in the region (Fig. 1). Kuru (1980) and Mater *et al.* (1989) reported its range along the whole Turkish coastline in the Black Sea and the Sea of Marmara at depths from 2-30 m. Geldiay and Balik (1996) represented a distribution map for this species including the lower to middle reaches of tributaries, freshwater lakes and lagoons in the Black Sea and Marmara

Region. The round goby in the southern Black Sea is included in commercial fishery rates as by-catch in trawl fishery and always demanded in local markets.

Outside of its native range, the Ponto-Caspian region, the round goby invaded different aquatic ecosystems far away from its origin. The first invasion has been noticed by the catch of the first round gobies near the port of Hel in the Gulf of Gdansk (Baltic Sea) in 1990 (Skora and Stolarski, 1993). In the following decade, it has spread from western part of the Gulf of Gdansk to the south and east, along the coastal zone of the gulf and become one of the most abundant fish species in this ecosystem (Sapota, 2004; Sapota and Skora, 2005; Skora 1996). In recent years, the round goby has also occurred in freshwaters of southeast Europe and its dispersal

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Figure 1. - Distribution of round goby *Neogobius melanostomus* in the southern Black Sea and the Sea of Marmara (black shadow area). [Distribution du gobie rond *N. melanostomus* dans le sud de la mer Noire et en mer de Marmara (figuré en noir).]

in Danube basin was confirmed (Simonović *et al.*, 1998; Simonović *et al.*, 2001; Strānai and Andreji, 2004). The first sight of the round goby individuals in St Clair River in 1990 in Canada was the sign of another invasion into the Laurentian Great lakes (Crossman *et al.*, 1992; Jude *et al.*, 1992). The round goby has successfully invaded this large aquatic ecosystem by the end of 1995 (Steingraeber *et al.*, 1996). This unintentional introduction probably occurred via ballast waters of foreign ships from the area of the Black, Caspian and Azov Seas or from the Baltic Sea (Charlebois *et al.*, 1997).

The studies on age and growth of round goby have previously carried out on populations from its native range; the Black and the Caspian Sea, the Sea of Azov (Kostyuchenko, 1961; Skazkina and Kostyuchenko, 1968; Tsyplakov, 1974; Kovtun *et al.*, 1976) and from the Gulf of Gdansk (Skora and Stolarski, 1996) and from the Great Lakes and River systems (Crossman *et al.*, 1992; Jude *et al.*, 1992; Steingraeber *et al.*, 1996; MacInnis and Corkum, 2000). Unfortunately, no previous study has been conducted on age and growth of the round goby distributed along the southern Black Sea coast.

The validation of an ageing technique is essential to provide accurate and precise age data, but it is rarely attempted using direct or indirect methods (Beamish and McFarlane, 1983). One of these indirect and widely used methods is marginal increment analysis that verifies annual deposition of otolith growth increments. The unimodal frequency distribution of otolith margins (opaque or translucent) throughout a year validates the deposition of a single annulus per year and explains the timing of the annulus formation.

The objectives of our study were to determine the ages from otolith readings and to validate age estimates indirectly by means of marginal increment analysis, to estimate the growth parameters from length-at-age values and to investigate the relationship between otolith and fish size.

MATERIALS AND METHODS

The samples for this study were obtained from commercial trawl fishery operating along Samsun city offshore nearly in the middle of the southern Black Sea coasts (41°22'N and 36°10'E) by monthly periods between October 2002 and March 2005, except in the summer months June-August. Specimens were caught in water between 30 and 150 m depth. A total of 868 individuals were measured to the nearest millimetre for total length (TL) and to the nearest gram for weight (W). The sex was recorded by macroscopic examination of sexually dimorphic urogenital papilla and gonads. The date of capture was also recorded. The length-frequency distributions of males and females were compared and tested for any statistically significant difference by means of Kolmogorov-Smirnov test.

Otolith preparation and age determination

The right- and left-side sagittae of each fish were removed, preserved dry and separately weighed to the nearest 0.1 mg (OW). The weights of the right- and left-side sagittae for each individual were tested for any significant difference using two sample paired t-test. The total otolith length (OL) was determined measuring the distance between the posterior and anterior tip of otolith along the central core and the otolith breadth (OB) along the dorsoventral axis to the nearest 0.1 µm using a micrometer eyepiece. All specimens were examined whole under a binocular stereomicroscope (Leica MZ 125) at 10X magnification using reflected light while immersed in alcohol and against a dark background.

Ages were assigned based on counts of alternating opaque and translucent zones along the axis from core to the rostral tip. Two age readings with at least one month interval were performed by two readers without reference to fish lengths. The precision of age estimates was calculated with the Index of Average Percent Error (IAPE), (Beamish and Fournier, 1981) and the percent of full agreement between readers was also calculated. Otoliths with excessive vateritic growth, deformation and indistinct annulus character were excluded from the age analysis. As it is conventionally accepted, the date of birth was assumed as January 1 for assignment of age classes.

The periodicity and timing of annulus formation was validated by marginal increment analysis (MIA). MIA based on following the progression of the rings formed on the edge of otolith throughout the year. A plot of the monthly percentage of otoliths with opaque and translucent margins will point out the annulus formation period. If one maximum per year will be found for opaque and translucent zones, then it can be considered that only one annulus is deposited throughout the year. The period at which the percentage of opaque margin reached its maximum indicates that fish is in a period of fast growth (Morales-Nin, 1992).

Growth parameters

The von Bertalanffy growth function (VBGF) was fitted to observed length-at-age data using nonlinear least squares estimation procedures. The VBGF is defined by the equation:

$$L_t = L_{\infty} \{1 - \exp[-K(t - t_0)]\}$$

where L_t is the total length at age t ; L_{∞} is the asymptotic length; K is the growth coefficient, t is age of the fish and t_0 is the hypothetical age at zero length. Overall growth performance was estimated by the index ϕ' (phi prime test) (Munro and Pauly, 1983; Pauly and Munro, 1984):

$$\phi' = \ln K + 2 \ln L_{\infty}.$$

Length-weight relationship and otolith growth

The relationships between TL and W were determined by fitting the data to the commonly used equation; $W = aL^b$ (Ricker, 1975), where L is the total length (cm), W is the total weight (g), a and b are constants. Regression analysis was employed on data for males and females separately after linearization by log-transformation to satisfy assumptions of normality. Analysis of covariance was performed to determine if there were significant differences in the weight-at-length relationships between sexes (Zar, 1999).

The otolith dimensions (OD); OL, OB and OW were

related to TL and age of the fish using generalized linear and nonlinear regression techniques to investigate the best model fitting the relationship between otolith size and fish size.

RESULTS

Otolith morphology, interpretation and otolith growth

Totally from 868 examined otoliths, 27 specimens were rejected as they could not be evaluated due to vateritic deposition and deformations. No significant difference was found between the weights of the right- and left-side sagittae of each pair (paired t-test; $t = 1.05$; $n = 785$; $p > 0.05$). So, any of them was used for ageing process in the case of deformation or loss of the other one. It is observed that the sagittae of round goby are elliptical in shape, slightly concave on distal face and have a sulcus on proximal face. The otolith core is opaque and always surrounded by a translucent zone. The first annulus is always clear and followed by easily interpretable, alternating opaque and translucent concentric growth zones (Fig. 2A-E). An indentation on ventral side of sagittae is observed in 16% of the samples (Fig. 3). It is observed that this indentation is closed, leaving a trace of split in some of the otolith pairs. Nevertheless it does not

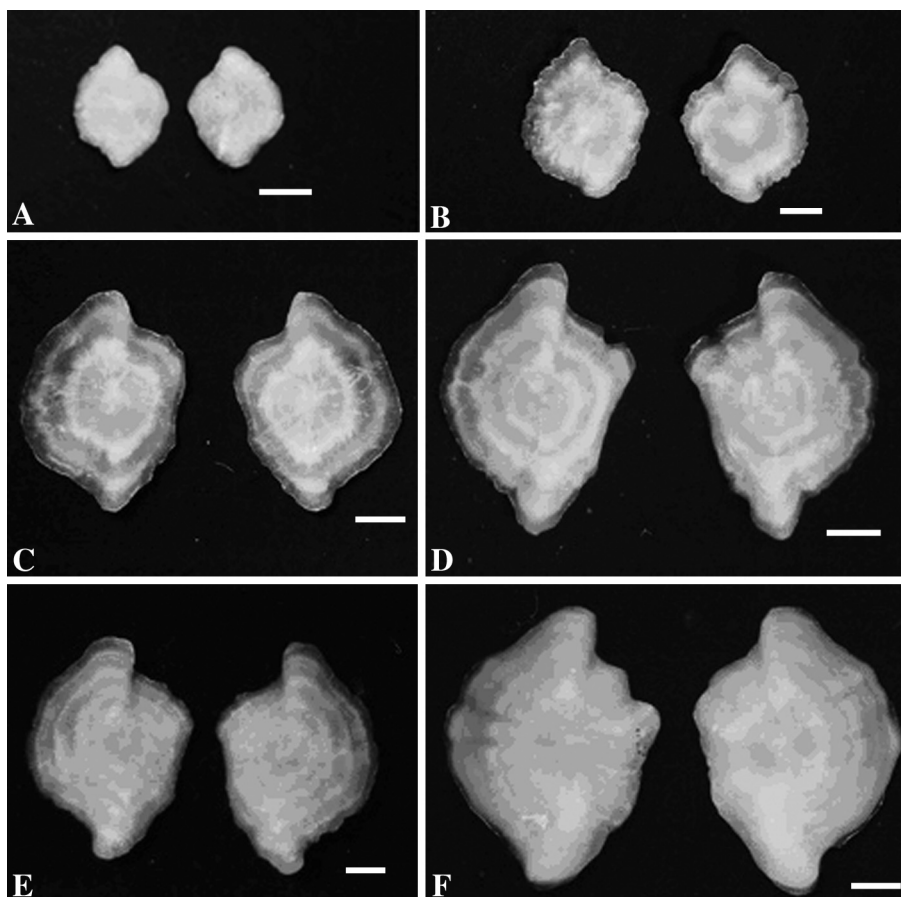


Figure 2. - Otoliths of the round goby *Neogobius melanostomus* from the southern Black Sea viewed with reflected light showing opaque and translucent zones counted for age estimation. A: 7.9 cm TL male in the first year of growth (0+); B: 11.6 cm TL male at age 1; C: 13.5 cm TL female at age 2; D: 19.3 cm TL male at age 3; E: 20.0 cm TL male at age 4; F: 20.3 cm TL male at age 5. [Otolithes de gobie rond N. melanostomus du sud de la mer Noire vues en lumière réfléchie montrant les zones opaques et les zones translucides comptées pour les estimations d'âge. A : Mâle de Lt = 7,9 cm en première année de croissance (0+) ; B : Mâle de Lt = 11,6 cm âgé de 1 an ; C : Femelle de Lt = 13,5 cm âgée de 2 ans ; D : Mâle de Lt = 19,3 cm âgé de 3 ans ; E : Mâle de Lt = 20 cm âgé de 4 ans ; F : Mâle de Lt = 20,3 cm âgé de 5 ans.]

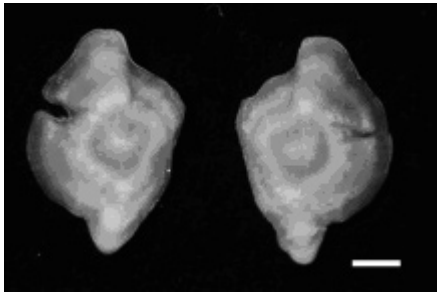


Figure 3. - Pair of otoliths of 15.0 cm TL male at age 2+ round goby *Neogobius melanostomus*. Open indentation in left-side otolith and no indentation on right-side otolith. [Paire d'otolithes d'un mâle de gobie rond *N. melanostomus* de 15,0 cm LT à 2 ans, montrant une échancrure ouverte sur celui de gauche et aucune indentation sur celui de droite.]

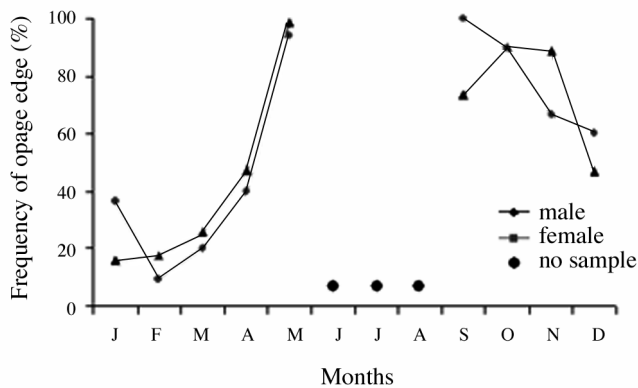


Figure 4. - Monthly frequency evolution of otoliths with opaque and translucent edge for males and females of round goby *Neogobius melanostomus* from the southern Black Sea. [Fréquence d'accroissement mensuel des otolithes avec contours opaques et translucides pour les gobies ronds *N. melanostomus* mâles et femelles du sud de la mer Noire.]

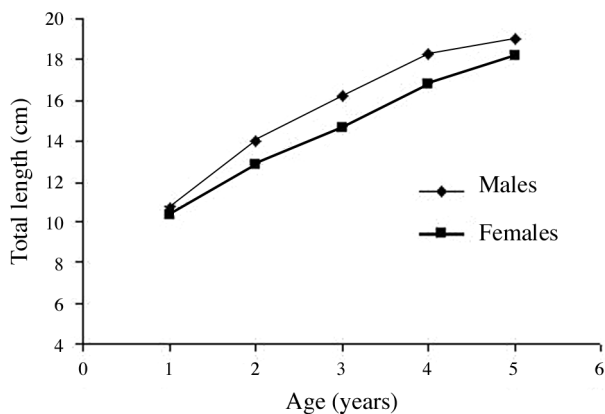


Figure 5. - Von Bertalanffy growth curves for males and females of round goby *Neogobius melanostomus* from the southern Black Sea. [Courbes de croissance de Von Bertalanffy pour les gobies ronds *N. melanostomus* mâles et femelles du sud de la mer Noire.]

impede the age counts realized in the rostral direction.

The precision of age estimates was satisfactory. We obtained full agreement between readers in 86% of all readings and low IAPE values within reader, 2.5% for the first and 4.7% for the second reader. Age estimates ranged from 1 to 5 years. Age 2 was the most dominant group (50.9%) in the samples and followed by age 3 (26.0%), age 1 (18.9%), age 4 (3.7%) and age 5 (0.5%).

MIA demonstrated that one growth zone (consisting of an opaque and a translucent zone) is deposited in otoliths of round goby during a period of 1 year (Fig. 4). Even though, a lack of data for the period between June and August was in discuss throughout a year, we were able to observe that the opaque zone began to be laid down in March and reached a high frequency in May in otoliths of both sexes (99% in males and 94% in females). The translucent zone is formed between September and February in male otoliths, mainly in January and February when opaque zone reached a minimum percent of frequency. The timing of translucent zone formation for female otoliths appears to be largely synchronous with males.

Growth model

The age estimates from otolith counts show that by the first, second, third, fourth and fifth years of life, males reach the mean total lengths of 10.7, 14.0, 16.2, 18.3 and 19.0 cm compared with 10.3, 12.9, 14.7, 16.8 and 18.2 cm in females, respectively. Both sexes indicate rapid growth in the first and second years of life growth. Females of same age are heavier but shorter than males.

Age-length keys for males and females are given in table II. The length values are highly variable within age groups as the data are pooled over a large period of the year. This causes widely overlapping length distributions for neighbouring age classes. Mean length-at-age values were significantly different between sexes except for age group one. Males tend to grow slightly faster in length than females.

The mean lengths of individuals assigned to each age group were used to fit the von Bertalanffy growth model (Fig. 5). Asymptotic TL was 21.5 cm for males and 23.7 cm for females. Males grew faster ($K = 0.38 \text{ year}^{-1}$) than females ($K = 0.22 \text{ year}^{-1}$). The growth equation for males was found to be:

$$L_t = 21.5[1 - e^{-0.375(t+0.83)}]$$

and for females:

$$L_t = 23.7[1 - e^{-0.223(t+1.59)}]$$

The index ϕ' values were estimated as 5.154 for males and 4.83 for females.

Length frequency distributions and length-weight relationships

Of the fish examined, 471 were males and 397 females. Male fish ranged in size from 7.4 to 25.0 cm (median = 14.4

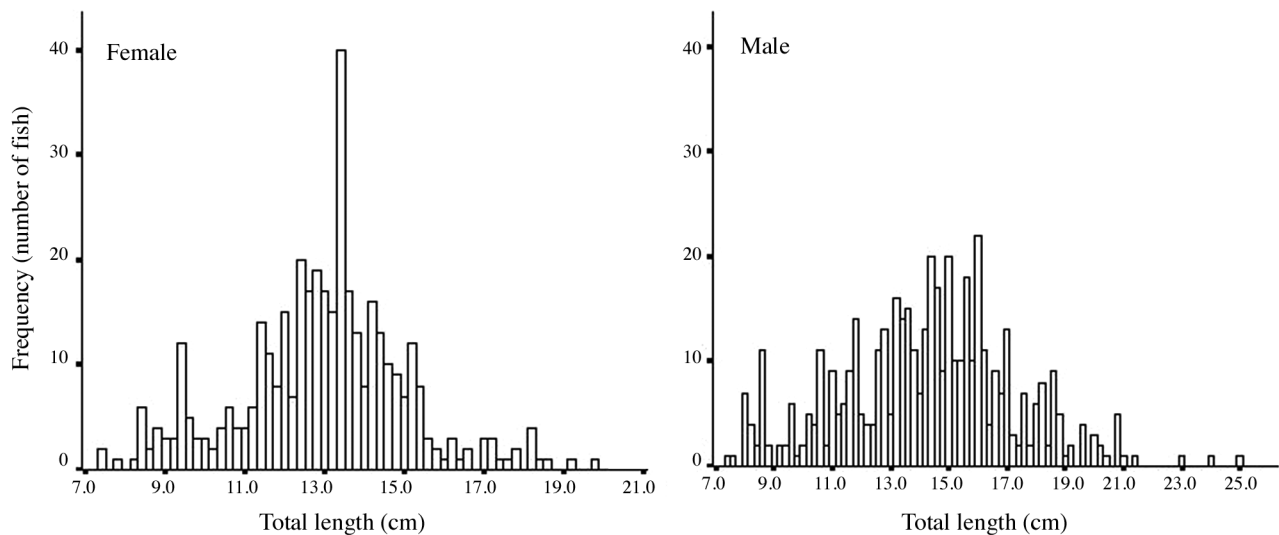


Figure 6. - 2002-2005 length frequency distributions (2-mm length classes) of male and female round goby *Neogobius melanostomus* from the southern Black Sea. [Distributions de fréquences de longueur (classes de 2 mm de longueur) des gobies ronds *N. melanostomus* mâles et femelles trouvés dans le sud de la mer Noire, échantillonnés de 2002 à 2005.]

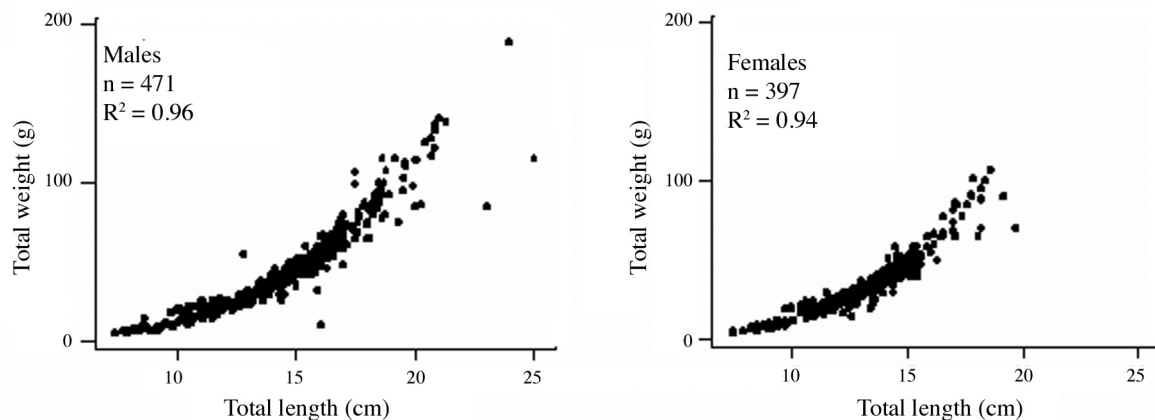


Figure 7. - Length-weight relationships for males and females of round goby *Neogobius melanostomus* from the southern Black Sea. [Relations longueur-poids de gobies ronds *N. melanostomus* mâles et femelles du sud de la mer Noire.]

cm) and females from 7.5 to 19.7 cm (median = 13.0 cm). The length-frequency distribution for males and females was significantly different (Kolmogorov-Smirnov two sample test, $d = 4.22$, $p < 0.001$) (Fig. 6). Males tend to be larger in the catches than females.

Length-weight relationships were calculated separately for males and females (Fig. 7).

Males: $W = 0.0110 L^{3.07}$ ($r^2 = 0.96$, $n = 453$)

Female: $W = 0.0076 L^{3.23}$ ($r^2 = 0.94$, $n = 397$)

The sex specific differences in the regression coefficient b are statistically significant (ANCOVA, $F = 10.80$; d.f. = 848; $p < 0.001$). The slope was also significantly higher than the theoretical value of 3 for males (t-test, $t = 110.36$, S.E._b = 0.027, $p < 0.001$) and for females (t-test, $t = 79.87$, S.E._b = 0.040, $p < 0.001$) indicating positive allometric growth for both sexes.

Relationships between OD-TL and OD-Age for males and females were represented in table I. Power functions between OD-TL and OD-Age provided a better fit than linear relationships. The power value b was below 1 for OL-TL and OB-TL relationships and above 1 for OW-TL relationships. Fish length and age always explain a greater part of variation in OW as compared to OL and OB. A considerable variation in the otolith weight within each age class causes a wide overlap especially among age classes 1-2 and age classes 2-3.

DISCUSSION

Charlebois *et al.* (1997) has outlined a problem as whether a reduction in the range of round goby occurs in the south-

Dependent variables	Independent variables	Sample size	a	b	r ²	p <	Standard error of estimate
OL _{male}	TL	471	0.55	0.76	0.89	0.001	0.058
OB _{male}	TL	471	0.70	0.53	0.79	0.001	0.059
OW _{male}	TL	471	0.11	1.61	0.92	0.001	0.116
OL _{female}	TL	397	0.45	0.83	0.80	0.001	0.070
OB _{female}	TL	397	0.57	0.61	0.67	0.001	0.073
OW _{female}	TL	397	0.06	1.84	0.85	0.001	0.133
OL _{male}	Age	471	3.24	0.29	0.50	0.001	0.484
OB _{male}	Age	471	2.44	0.21	0.43	0.001	0.098
OW _{male}	Age	471	4.81	0.67	0.56	0.001	0.247
OL _{female}	Age	397	3.09	0.30	0.48	0.001	0.114
OB _{female}	Age	397	2.32	0.23	0.43	0.001	0.096
OW _{female}	Age	397	4.42	0.69	0.56	0.001	0.225

Table I. - Relationships between otolith dimensions and total length or age of round goby *Neogobius melanostomus*. The predictive equations are of the curvilinear form $y = aX^b$. [Relations entre les dimensions des otolithes et la longueur totale ou l'âge des gobies ronds *N. melanostomus*. Les équations prévisionnelles sont de type curvilinéaire : $y = aX^b$.]

Table II. - Age-length key for males and females of round goby *Neogobius melanostomus* from the southern Black Sea based on whole otolith readings. [Clés âge-longueur pour les gobies ronds *N. melanostomus* mâles et femelles du sud de la mer Noire fondées sur les lectures d'otolithes.]

Length intervals (cm)	Age group (years)									
	Males					Females				
	1	2	3	4	5	1	2	3	4	5
6.5-7.5	1					10				
7.5-8.5	18					23	1			
8.5-9.5	16					12	6			
9.5-10.5	14	8				3	29	2		
10.5-11.5	14	18				13	45	3		
11.5-12.5	11	22	2			6	89	12	1	
12.5-13.5	12	37	8	3		1	41	24	1	
13.5-14.5	8	44	20			1	19	26		
14.5-15.5		38	27	1			1	8	1	
15.5-16.5		27	29	2			1	7	1	
16.5-17.5		9	21	2			1	2	4	1
17.5-18.5		5	18	1	2		1	1	1	
18.5-19.5			11	4						
19.5-20.5		1	2	4	1					
20.5-21.5			1	6						
21.5-22.5										
22.5-23.5			1							
23.5-24.5										
24.5-25.5			1							
Total	95	209	141	23	3	69	233	85	9	1
Mean (Standard error of estimate)	10.68 (0.21)	14.00 (0.14)	16.19 (0.17)	18.27 (0.55)	19.00 (0.66)	10.27 (0.21)	12.92 (0.08)	14.71 (0.16)	16.78 (0.69)	18.20 (*)

ern Black Sea since Berg (1949). It is evident that no reduction has occurred in its biogeographical range as we have samples, which have not been evaluated in this study but collected from the coastline along the southern Black Sea from Sinop to Rize cities.

The otolith method used for age determination of round

goby in the present study has been suggested for this species firstly by Kostyuchenko (1961) and later used by Bilko (1971). MacInnis and Corkum (2000) preferred lapilli pairs of otoliths. Simonović *et al.* (1998) used scales in aging of round goby in the River Danube. Interpretation of sagittal otoliths of round goby was simple and unproblematic, in this

Table III. - Comparison of age- and sex-specific length of *Neogobius melanostomus* from Southern Black Sea with previously reported studies. (*) range of length measurements, (**) mean length. [Comparaison des longueurs selon l'âge et le sexe de *N. melanostomus* du sud de la mer Noire avec les données d'études antérieures.]

Source	Geographic region	Sex	Age group	Length (type of measurement) (cm)
Berg, 1949; Nikol'skii, 1954	Black Sea, Caspian Sea and Sea of Azov	M	1	10.0-13.0 (SL)*
		F	3-4	17.0-18.0 (SL)
			1	8.0-11.0 (SL)
			3-4	13.0-14.0 (SL)
			5	25.0 (SL)**
Jude <i>et al.</i> , 1992	St Clair River, Michigan, USA	M+F	0+	2.9-6.1 (TL)
			1	6.1-11.8 (TL)
Skora and Stolarski, 1996	Gulf of Gdansk, Baltic Sea	M+F	2	15.2 (SL)
			3	18.2 (SL)
			4	21.2 (SL)
			5	24.6 (SL)
Steingraeber <i>et al.</i> , 1996	Little Calumet River, Illinois Water System, USA	M+F	1	7.0-9.0 (TL)
			2	12.1-14.0 (TL)
Simonović <i>et al.</i> , 2001	Danube River, Yugoslavia	M+F	0	4.22 (SL)
			1	7.68 (SL)
			2	9.28 (SL)
MacInnis and Corkum, 2000	Upper Detroit River (USA)	M	1	6.28 (SL)
			2	7.59 (SL)
		F	1	5.84 (SL)
			2	6.46 (SL)
			3	8.27 (SL)
Stráňai and Andraji, 2004	Danube River and Hron, Slovakia	M	-	9.0 (SL)
		F	-	8.6 (SL)
Present study	Southern Black Sea	M	1	10.7 (TL)
			2	14.0 (TL)
			3	16.2 (TL)
			4	18.3 (TL)
			5	19.0 (TL)
		F	1	10.3 (TL)
			2	12.9 (TL)
			3	14.7 (TL)
			4	16.8 (TL)
			5	18.2 (TL)

study. The high agreement of 86% obtained between two independent readers and the high individual precision indicated by low IAPE values of 2.5% for the first and 4.7% appears satisfactory for accepting of otolith as the appropriate ageing material. Also, the otolith ring structure could be confirmed by the MIA method as yearly structures but ideally a direct validation method such as known-age fish method is still needed (Beamish and McFarlane, 1983) in order to confirm that the age readings do not include bias.

Kostyuchenko (1961) reported that annulus formation was first evident in April or May in the Sea of Azov. According to MacInnis and Corkum (2000) annulus formation occurs between late May and early June in upper Detroit River. It is considered that both authors mean the newly growing zone in otolith by the term of 'annulus formation', which corresponds to 'opaque zone' in this study. The opaque zone formation appears to begin slightly later in the upper Detroit River than in the southern Black Sea and the Sea of Azov.

More attention has been paid to OW to examine its utility

in age predictions as an alternative method to annuli counts as it is common for many fish species (Franks *et al.*, 1999; Cardinale *et al.*, 2000; Newman and Dunk, 2002; Tuset *et al.*, 2005). But the assumption of normality is not valid for otolith weights within age group 1 due to lack of individuals smaller than 7.4 cm probably due to selectivity of the sampling method and within age group 4 having relatively low number of specimen. Furthermore, the great variability in otolith weights within each age group and overlapping values among age groups prevents to obtain an index which can be used to predict age from OW measurements.

Age-length keys revealed a clear and high variability in length within age groups, which may be a natural result of prolonged spawning in round goby. We observed that the round goby has a reproductive season, which extends from May to August as it was previously reported (Berg, 1949; Kovtun, 1977; Skora and Stolarski, 1996). This variability in length-at-age values may decrease the reliability while estimating the growth rate by length-based models.

The observed age range of five years was similar to those reported for round goby in other parts of the Black Sea, in the Caspian and Azov Sea and in the Baltic Sea, whereas in river systems this species has a life span ranging from 1-3 years (Tab. III).

In accordance with Berg (1949), Nikol'skii (1954), Skora and Stolarski (1996) and MacInnis and Corkum (2000), males were reported to grow faster but have smaller asymptotic length than females in this study. The rapid growth of males may be attributed to late maturation (3-4 years old) when compared to females (2 years old) (Nikol'skii, 1954).

Jude *et al.* (1992) estimated the length-weight relationship of round goby in the St. Clair River with combined sexes. Wolfe and Marsden (unpubl. data referenced by Charlebois *et al.*, 1997) and Skora and Rzeznik (2001) were recorded no significant difference between the length-weight relationship of round goby males and females respectively in Calumet Harbor (IL) and in the Gulf of Gdansk. In contrast, we determined significant differences between the slopes of length-weight equations obtained from both sexes.

Therefore, a further study comprising the age data belonging the early and the very late period of life span of round goby may contribute in a better understanding of its growth model and to improve the utility of OW measurements in age estimation which may provide a more objective criterion than those based on annuli counts.

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REFERENCES

- BEAMISH R.J. & FOURNIER D.A., 1981. - A method for comparing of a set of age determinations. *Can. J. Fish. Aquat. Sci.*, 38: 982-983.
- BEAMISH R.J. & McFARLANE G.A., 1983. - The forgotten requirement for age validation in fisheries biology. *Trans. Am. Fish. Soc.*, 112: 735-743.
- BERG L.S., 1949. - Freshwater Fishes of the USSR and Adjacent Countries. Vol. III. 510 p. Acad. Sci. USSR Zool. Inst. (Translated from Russian by the Israel Program for Scientific Translations, Jerusalem, 1965).
- BILKO V.P., 1971. - Comparative description of the growth of gobies (Gobiidae) and Lee's phenomenon. *J. Ichthyol.*, 8: 543-555.
- CARDINALE M., ARRHENIUS F. & JOHNSON B., 2000. - Potential use of otolith weight for the determination of age-structure of Baltic cod (*Gadus morhua*) and plaice (*Pleuronectes platessa*). *Fish. Res.*, 45: 239-252.
- CHARLEBOIS P.M., MARSDEN J.E., GOETTEL R.G., WOLFE R.K., JUDE D.J. & RUDNIKA S., 1997. - The round goby, *Neogobius melanostomus* (Pallas), a review of European and North American literature. Illinois-Indiana Sea Grant Program and Illinois Natural History Survey. IHNS Special Publication No. 20, 76 p.
- CROSSMAN E.J., HOLM E., CHOLMONDELEY R. & TUININGA K., 1992. - First record for Canada of the rudd, *Scardinius erythrophthalmus*, and notes on the introduced round goby, *Neogobius melanostomus*. *Can. Field-Nat.*, 106: 206-209.
- FRANKS J.S., WARREN J.R. & BUCHANAN M.W., 1999. - Age and growth of cobia, *Rachycentron canadum*, from the North-eastern Gulf of Mexico. *Fish. Bull.*, 97: 459-471.
- GELDİAY R. & BALIK S., 1996. - Turkish Freshwater Fishes. Ege Üniversitesi Su Ürünleri Fakültesi Yayınları No: 46, Ege Üniversitesi Basımevi, Bornova, İzmir (II. Baskı). [In Turkish]
- JUDE D.J., REIDER R.H. & SMITH G.R., 1992. - Establishment of the Gobiidae in the Great Lakes basin. *Can. J. Fish. Aquat. Sci.*, 49: 416-421.
- KOSTYUCHENKO V.A., 1961. - Age and growth of the round goby *N. melanostomus* (Pallas) in the Azov Sea. *Tr. AzChernIRO*, 19: 45-60.
- KOVTUN I.F., 1977. - On the fecundity of the round goby, *Gobius* [*sic*] *Neogobius* *melanostomus* (Pallas), from the Sea of Azov. *J. Ichthyol.*, 17: 566-573.
- KOVTUN I.F., NEKRASOVA M.Y., DOMBROVSKIY Y.A. & REVINA N.I., 1976. - Application of regression analysis for forecasting the size of the round goby stock in the Sea of Azov. *Hydrobiol. J.*, 12: 37-41.
- KURU M., 1980. - Turkish Freshwater Fishes Catalog. Hacettepe Üniversitesi Fen Fakültesi Yayınları Yardımcı Kitaplar Dizisi: 1, H.Ü. Fen Fakültesi Basımevi, Beytepe, Ankara. [In Turkish]
- MACINNIS A.J. & CORKUM L.D., 2000. - Age and growth of round goby *Neogobius melanostomus* in the Upper Detroit River. *Trans. Am. Fish. Soc.*, 129: 852-858.
- MATER S., KAYA M. & BİLECENOĞLU M., 1989. - Turkey Atlas of Marine Fishes. Ege Üniversitesi Su ürünleri Fakültesi Yayınları No: 68, Ege Üniversitesi Basımevi, Bornova, İzmir. [In Turkish]
- MILLER P.J., 1986. - Gobiidae. In: Fishes of the Northeast Atlantic and Mediterranean (Whitehead P.J.P., Bauchot M.-L., Hureau J.-C., Nielsen J. & Tortonese E., eds), pp. 1019-1086. Paris: UNESCO.
- MORALES-NIN B., 1992. - Determination of growth in bony fishes from otolith microstructure. *FAO Fish. Techn. Paper*, No. 322. Rome: FAO.
- MUNRO J.L. & PAULY D., 1983. - A simple method for comparing growth of fishes and invertebrates. *ICLARM Fishbyte*, 1: 5-6.
- NEWMAN S.J. & DUNK I.J., 2002. - Growth, age validation, mortality, and other population characteristics of the red emperor snapper, *Lutjanus sebae* (Cuvier, 1828), off the Kimberly Coast of north-western Australia. *Estuar. Coast. Shelf S.*, 55: 67-80.
- NIKOL'SKII G.V., 1954. - Special ichthyology. Sovetskaya nauka. (Translated from Russian by the Israel Program for Scientific Translations, Jerusalem, 1961.)
- PAULY D. & MUNRO J.L., 1984. - Once more on the comparison of growth in fishes and invertebrates. *ICLARM Fishbyte*, 2: 21.
- RICKER W.E., 1975. - Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd. Can.*, 191: 1-382.
- SAPOTA M.R., 2004. - The round goby (*Neogobius melanostomus*) in the Gulf of Gdansk-a species introduction into the Baltic Sea. *Hydrobiologia*, 514: 219-224.
- SAPOTA M.R. & SKORA K.E., 2005. - Spread of alien (non-indigenous) fish species *Neogobius melanostomus* in the Gulf of Gdansk (south Baltic). *Biol. Invasions*, 27: 290-299.

- SIMONOVIĆ P., PAUNOVIĆ M. & POPOVIĆ S., 2001. - Morphology, feeding and reproduction of the round goby, *Neogobius melanostomus* (Pallas), in the Danube river basin, Yugoslavia. *J. Great Lakes Res.*, 27: 281-289.
- SIMONOVIĆ P., VALKOVIĆ B. & PAUNOVIĆ M., 1998. - Round goby *Neogobius melanostomus*, a new Ponto-Caspian element for Yugoslavia. *Folia Zool.*, 47: 305-312.
- SKAZKINA E.P. & KOSTYUCHENKO V.A., 1968. - Food of *N. melanostomus* in the Azov Sea. *Vopr. Ikhtiol.*, 8: 303-311.
- SKORA K.E., 1996. - *Neogobius melanostomus*. In: Report of the Working Group on Introduction and Transfers of Marine Organisms (WGITMO). ICES Annual Science Conference, pp. 96-107. Iceland: Reykjavik.
- SKORA K.E. & RZEZNIK J., 2001. - Observations on the diet composition of *Neogobius melanostomus* Pallas 1811 (Gobiidae, Pisces) in the Gulf of Gdansk (Baltic Sea). *J. Great Lakes Res.*, 27: 290-299.
- SKORA K.E. & STOLARSKI J., 1993. - New fish species in the Gulf of Gdansk, *Neogobius* sp. [cf. *Neogobius melanostomus* (Pallas 1811)]. *Notes Bull. Sea Fish. Inst.*, 1: 83.
- SKORA K.E. & STOLARSKI J., 1996. - *Neogobius melanostomus* (Pallas 1811), a new immigrant species in the Baltic Sea. In Proc. of the 2nd International Estuary Symposium, Gdynia. Crangon Iss. MBC Gdynia, 1: 101-108.
- STEINGRAEBER M., RUNSTROM A. & THIEL P., 1996. - Round goby (*Neogobius melanostomus*) distribution in the Illinois waterway system of metropolitan Chicago. 23 p. U.S. Fish and Wildlife Service Report.
- STRÁŇAI I. & ANDREJI J., 2004. - The first report of round goby, *Neogobius melanostomus* (Pisces, Gobiidae) in the waters of Slovakia. *Folia Zool.*, 53: 335-338.
- TSYPLAKOV E.P., 1974. - Expansion of the ranges of some fishes in connection with hydraulic engineering works on the Volga and acclimatization operations. *J. Ichthyol.*, 14: 343-351.
- TUSET V.M., GARCÍA-DÍAZ M.M., GONZÁLEZ J.A., LORENTE M.J. & LOZANO I.J., 2005. - Reproduction and growth of the painted comber *Serranus scriba* (Serranidae) of the Marine Reserve of Lanzarote Island (Central-eastern Atlantic). *Estuar. Coast. Shelf S.*, 64: 335-346.
- ZAR J.H., 1999. - Biostatistical Analysis. 4th edit. 663 p. Upper Saddle River, New Jersey: Prentice Hall.

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